PARASITES OF THE TERMITES.

Presented by the Author
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The Parasites of the Termites.

PLATES 51, 52.

By Joseph Leidy, M.D.

In common with many other observers, the writer has always felt an interest in the history of Ants, including also those insects of another order, the Termites or White-ants. A species of the latter, the *Termes flavipes*, belonging to this country, occurs abundantly in the dry sandy forests and fields of southern New Jersey; in some places being found beneath almost every piece of decaying timber and in every old stump. It is frequent beneath discarded railroad ties as they lie decaying at the sides of the road, but I have heard of no complaint of the insect attacking the sound ties in use, nor indeed the sound timbers of any kind in the neighboring fences and buildings. In the vicinity of Philadelphia, the Termites, though less frequent and abundant than in New Jersey, are yet common enough, and are often to be found beneath stones as well as in old rotting timbers.

The passage-ways of the insects, beneath stones, and the galleries they hollow in wood, are plastered with a brownish material apparently consisting of their own excrements.

In watching the Termites from time to time wandering along their passages beneath stones, I have often wondered as to what might be the exact nature of their food in these situations. Observing some brownish matter within the translucent abdomen of the insects, I was led to examine it with the object of ascertaining its character. On removing the intestinal canal of an individual I observed the brownish matter was contained within the small intestine, which is comparatively large and capacious. The brownish matter proved to be the semi-liquid food; but my astonishment was great to find it swarming with myriads of parasites, which indeed actually predominated over the real food in quantity. Repeated examination showed that all individuals harbored the same world of parasites wonderful in number, variety, and form.

Wishing to learn something more of the extraordinary parasitic community of the Termites thus accidentally discovered, I was led to refer to the literature concerning these insects; but I found no description of the parasites. The only authority I met who appears to have noticed them is M. Ch. Lespes in an excellent

"Memoir on the Organization of *Termes lucifugum* of France," published in the Annales d. Sciences Naturelles, vol. v., 1856. Page 237, in describing the digestive apparatus of the workers, he says: "Au ventricle fait suite une poche volumineuse, courbe, boursouflée, et pleine d'une matière brune dans laquelle fourmillent les nombreux Infusoires dont j'aurai à m'occuper plus tard. D'après la nomenclature généralement adoptée ce devrait être l'intestin grêle." Further, on the same page, he says: "L'intestin est ordinairement rempli d'une sorte de bouillie brune, vivante agglomeration d'Infusoires."

Page 258, M. Lespés remarks in regard to the winged males and females, "le tube digestive contient rarement la bouillie brune que nous avons trouvée chez les ouvriers et les soldats; c'est une matière de couleur beaucoup moins foncée que le remplit. Il fourmille toujours d'animalcules que je d'écrirai plus tard." At the conclusion of an article entitled "Note on a Nematoid Parasite of the Termites," page 335 of the same volume, M. Lespés says: "J'ai trouvé dans le tube digestive des Termites un assez grand nombre de parasites, sur lesquels je me promets de revenir avant long temps."

A quarter of a century has elapsed and yet it would appear that M. Lespés has given no further account of the parasites of the Termites, which may be regretted, for we have reason to believe that the author of the memoir on the organization of the *Termes lucifugum* would have given us an equally faithful account of the community of creatures it sustains.

Some animals are so habitually and constantly infested with multitudes of various parasites that it would appear to be their normal condition. Such is strikingly the case with our common large Julus *J. marginatus* or *Spirobolus marginatus*, and the still more common beetle, *Passalus cornutus*, as described by the writer in an article entitled "A Flora and Fauna within Living Animals," published in 1853, in the Smithsonian Contributions to Knowledge. So constant is the occurrence of parasites in the animals just indicated, that in reference to one of them I was led to remark that entophytes would be constantly found in the genus *Julus* in any part of the world (Proc. Acad. Nat. Sci. 1849, 228). It was perhaps this expression of opinion which led M. Charles Robin to examine the *Julus terrestris* of Europe, leading to the discovery of the *Enterobryus Juli terrestris*. (See Hist. Nat. des Vegetaux Parasites, etc., Paris, 1853, p. 398.) Only a few weeks since while strolling in the country I noticed a Julus crossing the road, when it occurred to me that it would afford me an opportunity of comparing one of its parasitic plants with one occurring in the Termite, and I therefore took possession of the truant. On examination, sure enough, there were all the para-

sites which I had observed in many individuals of the same, thirty years ago—three distinct species of nematoid worms, the infusorian *Nyctotherus*, the beautiful entophyte *Enterobryus elegans*, *Arthromitus cristatus*, etc.

Our White-ant, *Termes flavipes*, belongs to the same hospitable company of victuallers as the Wood-Julus, *Spirobolus marginatus*, and the Unicorn Wood-beetle, *Passalus cornutus*, and as constantly sustains a multitude of parasites, both animal and vegetable. It is a remarkable fact that the three creatures just named; a neuropterous insect, a beetle, and a myriapod, use the same food and even at times occupy the same habitation—an old stump, or decaying log. Viewing the immense communities they protect and feed, they would in a measure appear to be of subordinate importance, and may be regarded as powerful mills which reduce the ligneous food to a pulpy condition, adapted to the more delicate constitution of their occupants.

It may be inferred that other species of the same genera above mentioned, with similar habits, will be found equally infested with swarms of parasites. What an idea this gives one of the immensity of life when we reflect upon the probable fact that each and every individual of the already innumerable Termites of the tropics are equally peopled with our own! No wonder, considering the communities they have to feed, that they should be so great a pest to man, even to eating his house, furniture, and books! Here also is a new world to be explored; what a treat it would be to see the nations which inhabit the *Termes fatalis* and other species of western Africa, and those of Ceylon, India, and of South America!

When the intestine of the Termite, *Termes flavipes* is withdrawn from the abdomen and submitted to gentle pressure, under the microscope, the brownish matter in the interior is observed as a swarming mass, in which the largest of the parasites, mainly comprising the latter, are distinguished pushing their way through the crowd. If the intestine is ruptured, myriads of the living occupants escape, reminding one of the turning out of a multitude of persons from the door of a crowded meeting-house. So numerous are the parasites and so varied their form, movement, and activity, that their distinctive characters cannot be seen until they become more or less widely diffused and separated.

By far the greater proportion of the brownish pulpy contents of the small intestine of the Termite consists of parasites, and indeed the first impression might be that these were the actual food, while the small proportion of smaller and indefinite particles were accidental elements swallowed with the animalcules. To be sure these are at first all living and do not exhibit the usual appearance of

swallowed living prey; that is to say, all or nearly all dead and in different stages of digestion. Nevertheless, the proportion of materials which I had inferred to be the ordinary food of the Termite was so very small in comparison with the immense numbers of associated and incessantly present parasites, that I could not avoid the suspicion that these might possibly be collected from among the decaying wood in and on which the Termites were considered to live. An examination, however, of the wood in which the Termites lived, and of the plastering of their galleries, exhibited no traces of the parasites or of spores or eggs which could be referred to the latter.

Of the parasites of our Termite there appear to be three or four, or perhaps more distinct species of remarkable protozoans, but of this I am not positive, for I have suspected that several which I at first viewed as such may be only different stages of the same. On the other hand, certain forms which I have regarded as younger stages of species as I have distinguished them, may in future investigation prove to be equally distinct. These parasites are widely different from any previously described of which I have any knowledge, and they have exceedingly puzzled me as to their nearest relations. Their delicacy of structure, rapid movements and variation in shape, and liability to change from more or less rapid decomposition, render their characters intricate and difficult to unravel. In the following descriptions I have of course attempted to represent them as they have appeared to me from time to time, but I am not altogether satisfied with the results, and apprehend that in some cases I have not interpreted the appearances correctly. With the peculiar parasites indicated there are several others which are of a vegetal character, and these likewise are described in the following pages.

Our Termite also is infested with a nematoid worm in an immature condition, the *Isacis migrans*, discovered by M. Lespés, in the same state, in the *Termes lucifugum* of France, and likewise found by him in the mature condition in the earth of the nest of the Termite. Further, a gregarine, so common in insects, is also occasionally found in our Termite.

Termites, or White-ants, are so common, easily obtained and preserved alive, and their parasites are so exceedingly numerous, constant in their occurrence, and curious, that once the fact becomes sufficiently known, the insects will become favorite subjects to illustrate at once the infinity of life and the wonders that are revealed by the microscope. The parasites were first observed by the writer in 1877, and a brief notice of them was published in the Proceedings of this Academy for the same year.

TRICHONYMPHA.

trix, hair; nympha, nymph.

TRICHONYMPHA AGILIS. Plate 51.

Proceedings of the Academy of Natural Sciences, 1877, p. 147.

The most conspicuous and extraordinary of the parasites of our Termite is one to which I have given the above name. It is with some regret that I am obliged to confess that notwithstanding all my scrutiny I have been unable to determine the characters of this singular creature sufficiently to learn whether to regard it as a ciliate infusorian, a gregarine, or a rhabdocoelus turbellarian. I am, however, disposed to view it as the former, or rather as of intermediate character to the two former.

Commonly in the extended condition *Trichonympha* is about $\frac{1}{30}$th of an inch long, and about half the breadth of the length. In shape it resembles a gregarine; and it is clothed with cils of extraordinary length. (See Figs. 1–10.) When it first escapes from the intestine and is diffused on the object glass of the microscope it usually appears more or less distorted, and may be contracted to such a degree that the breadth exceeds the length, as represented in Figs. 1–3. By reflected light it appears white, and it is translucent.

Trichonympha presents a slight constriction at or a little in advance of the middle, so as to appear to consist of two portions, which with the general form give it very much the appearance of a gregarine. For convenience of description the two parts may be distinguished as head and body. (See Figs. 5–10.)

The head is conical, and usually appears shorter than the body, but is variable in this respect, depending on the degree of extension of the latter and the contraction of the former, or its depression within the body. Its apex is more or less produced as a mammillary eminence, which seems to be the chief if not the sole source of origin of the extraordinary long cils that extend backward and invest the animal as with a cloak.

The body is broader or more robust than the head, and of variable proportionate length, according as it is shortened by contraction or elongated by extension. It is conical, oval, cordiform, or more or less abruptly tapering according to the changes it undergoes in movement. The posterior extremity is obtusely rounded, or may become more or less subacute, or it may appear abruptly truncated. (See Figs. 1–10.)

In the fresh and most active condition of *Trichonympha* during its movements the head and body frequently vary in their relative proportions according to the degree of their contraction, shortening, and elongating. The head alternately

becomes somewhat elongated and narrower, and its summit more protuberant, and by contraction becomes in a corresponding degree shortened, widened, and more blunt. Often also the head turns backward, then forward. The body elongates and becomes narrowed, regularly tapering, and more or less pointed, rounded, or abruptly truncated; or it contracts and becomes shorter and oval, or abruptly bulges where it joins the head, and narrows abruptly towards the extremity; and sometimes it makes a half twist, or swells on one side and becomes depressed on the other. Frequently the head and body shorten and widen together, and the former sinks more or less deeply into the latter, as represented in Figs. 1 to 3.

Viewed on end *Trichonympha* appears circular, as seen in Fig. 4, inclosing a pair of inner circles produced by the outline of the head and a nucleus within.

The interior of *Trichonympha* is occupied by a mass nearly conforming in shape with the exterior, and like this consists of two corresponding portions. These would appear to relate to the two portions of the granular endosarc in a gregarine; and they have reminded me, at least in relative position and volume, with the capacious pharynx and stomach of a turbellarian worm.

As for convenience I have considered the two parts of the animal as head and body, for the same reason I shall speak of the outer and inner structures as ectosarc and endosarc, without regarding them actually as such in relation with an infusorian or other protozoan.

The anterior division of the endosarc occupies about three-fourths of the capacity of the head, appearing to be inclosed in a thick wall of ectosarc. It would seem to be conical, with the apex acuminate and the base abruptly terminating in the body endosarc on the line of conjunction of the head and body of the animal, as seen in Figs. 5–7, 9, 10. More closely examined, the head endosarc would appear to be ovoid, with the posterior broader extremity received into a depression of the body endosarc, as represented in Figs. 1–3, 8. The anterior acuminate end is extended to a point at the summit of the head.

The head endosarc is homogeneous, or very minutely and uniformly granular throughout. Its structure appears consistent and not fluent, or even semifluent as in the endosarc of gregarines and infusorians, but it presents no trace of striation or fibrillation to distinguish it as probably being of muscular nature. It is, however, elastic, and elongates and contracts in correspondence with movements of the head.

The body endosarc occupies a greater proportion of the interior capacity of the body than that of the head, but is less well defined from the inclosing ectosarc, especially at the posterior part, where it often appears insensibly to gradate

into the more homogeneous and transparent structure of the ectosarc. It is comparatively more distinctly and coarsely granular than the head endosarc, and is of much less uniformity. Its finer granular basis is mingled with larger granules of variable definition. It is also usually mixed with variable proportions of irregular, more darkly defined, and often angular particles, which appear to be fragments of solid food, bits of wood tissue, derived from the food materials of the host of *Trichonympha*. The supposed food particles are mostly directly mingled with the granular matter composing the mass of the body endosarc, and were rarely and but indistinctly observed to be included in globules of clearer matter, as is commonly the case in most protozoans which swallow solid food. In the movements and changes of shape of *Trichonympha* I never distinctly observed a freely fluent condition of the contents of the body endosarc, such as occurs in the rhizopods and other protozoans.

If the irregular particles so commonly observed in the body endosarc of *Trichonympha* are really solid food particles, I have been sorely puzzled and have failed to ascertain how they obtained entrance into the body. I have watched myriads of individuals hours together, without ever having seen one of them swallow or discharge a particle of food. I have been unable to detect anything like a mouth; and the ectosarc, unlike that of the rhizopods, has rather the unyielding character of that of *Gregarina*. I could detect no trace of a passage through the head endosarc, nor ever saw a particle within it which might be on its way to the body endosarc.

Occasionally I have observed among the more ordinary constituents of the body endosarc one or several clear globules or vacuoles. Though these have been obscurely seen to slowly enlarge and also to disappear, yet they did not present anything like the rhythmical movements of the contractile vesicle, so commonly an element of the protozoans.

In a few instances, in some individuals, I have further observed in the endosarc one or two large, coarsely granular spheres, as represented in Fig. 7. I have not been able to ascertain their nature, but have suspected that they are masses of ova-like bodies or spores.

The integument or ectosarc of *Trichonympha* appears to be homogeneous, and is transparent and elastic. It is also contractile, like that of *Gregarina*, but is in no wise extensible like that of rhizopods. Upon the head it is thicker than upon the body, and is more distinctly defined from the corresponding portion of the endosarc. It has appeared to me to present a delicate and regularly longitudinally striated condition, such as I have pointed out in the integument of *Grega-*

rina, and as represented in Figs. 5, 7, 9. I have, however, not been able positively to satisfy myself that this striated condition actually pertains to the ectosarc of *Trichonympha*, and have suspected that the appearance was an illusion produced by the long cils which invest the animal.

A large spherical nucleus is constantly to be observed in *Trichonympha* situated centrally at the conjunction of the two divisions of the endosarc, as seen in Figs. 1–10. It always maintains this position in all the movements of the animal. It has usually appeared to me to be imbedded within the fundus of the head endosarc, as seen in Fig. 8, though sometimes I felt in doubt whether this was actually the case. It is more or less distinctly and uniformly granular.

Commonly the nucleus of *Trichonympha* appears surrounded by a light ring or halo, but occasionally it is to be seen inclosed within a second and considerably larger and faintly granular sphere, as represented in Figs. 9, 10. No other definite structural elements than those above described were observed in the interior of *Trichonympha*, no appearance of reproductive elements, nor any trace of vessels.

The most remarkable character of *Trichonympha* is its wonderful cloak of vibrating cils. No other animal of which I have any information has the appendages of such great length. They appear to emanate altogether from the summit of the head, and spread outward and backward enveloping the animal, and extending a considerable distance beyond its posterior extremity. They originate in several series, or circles in succession, three or four as it seems to me, as represented in Figs. 1–3, 5, 7, 9, 10.

The first series of cils start immediately back of the pointed summit of the head, and are the shortest. They extend upon the sides of the head and incessantly wave outwardly.

The second series of cils proceed from a circle immediately behind the former, and extend outward and backward to the fore part of the body. These wave outwardly like those of the first rank of cils.

The third series, starting from the head beneath the former, spread downward and inward or outward over the body to its posterior extremity, or beyond it to an extent proportionate with the shortening of the animal. The second rank of cils gently and incessantly vibrate, and are continually lifted and depressed or open and close. The motion occurs regularly and uniformly all around, or it may occur to a variable degree partially, and more actively in one direction than in another. The motion reminded me of the gentle streaming of a delicate sheet of water from the edge of a fountain vase, and if displayed more on one side than another it resembled the same sheet swayed by the wind.

When *Trichonympha* curls its head into a helix, the three ranks of cils above described, appear to diverge in vortices from the inflection of the head, as I have attempted to represent in Figs. 6, 8.

The fourth rank of cils, the longest of all the series, springing from the head, fold backward in a spiral direction, closely envelop the body, and extend beyond its extremity in a twisted fasciculus with divergent ends. (See Figs. 1–3, 5–10.) These cils ordinarily appear to be motionless, but sometimes show a disposition to untwist and open outwardly. Usually they extend back of the body much farther than the third rank of cils, but in the varied movements of the animal in extreme shortening the latter may reach even beyond the former, as seen in Figs. 3, 8.

When *Trichonympha* is viewed on end, so as to appear circular in outline, its long cils diverge more or less uniformly all round in a tangential manner, and recall to mind a similar view of the peristome of a vorticella. At times in the same view the cils appear to diverge in several groups, and converge towards the ends, as represented in Fig. 4.

In its natural position *Trichonympha* may be detected amidst the dense concourse of its associates gliding through and displacing them as it advances. As usually observed upon the object glass of the microscope it remains nearly or quite stationary in position, though it may also frequently be seen advancing in a slow, shuffling manner, shouldering its way, as it were, through the crowd of parasites surrounding it. While it remains stationary in position it is otherwise briskly in motion. The head is more active than the body, continually elongating and shortening, and directing or bending its apex from side to side, or rolling it backward upon itself into a helix, now in one and then in an opposite direction. The body also elongates or shortens, becoming narrower or wider, or it widens at the base and abruptly tapers to either a pointed or more or less blunt extremity; or it assumes an oval form of variable length and breadth, or it may become quickly incurved on one side, or make a half twist upon itself. The shorter cils wave incessantly outwardly, while the longer ones are constantly rising and falling in a somewhat rhythmical manner.

Some individuals of *Trichonympha* undergo dissolution in the ordinary liquids of examination* almost immediately after being discharged from their natural habitation, while others remain comparatively unchanged for variable periods extending from a few minutes to the whole day. As the animal weakens it

* I have usually employed for the examination of the Termite parasites neutral salt solution, aqueous humor of the eye, and diluted albumen of the egg.

assumes a symmetrical quiescent form and the longer cils cease movement, while the shorter ones will still retain their activity. When it dies it becomes spherical, and the contents break up into clear vesicles mingled with more defined granules; and the contents of the nucleus shrink from its apparent wall.

Trichonympha commonly ranges from 0.075 to 0.09 mm. in length by 0.035 to 0.045 mm. in breadth. Large individuals in active movements may elongate to 0.115 mm. by 0.03 mm. in breadth, and the same by contraction, together with depression of the head may shorten to 0.06 mm. and widen to 0.05 mm. Individuals in an extreme state of shortening and proportionate widening, as often seen, when the animals are first observed, measured 0.036 mm. long by 0.051 mm. broad to 0.084 mm. long and 1.108 broad. Extreme length of an animal to the end of the terminal twist of cils measured 0.135 mm. The extreme lateral spread of the cils in an individual reached 0.24 mm. The central nucleus of *Trichonympha* is from 0.012 mm. to 0.015 mm. in diameter.

Among the tumultuous crowd of Termite parasites there are many which I have suspected to pertain to immature stages of *Trichonympha*, though I have not been able to verify the suspicion. The young, as I suppose them to be, present considerable variety in size and shape. Individuals of the kind are represented in Figs. 12–21, though it is difficult to obtain satisfactory views of their form and structure, partly on account of their delicacy, lively movements, and thick investment of cils, and partly from their quickly undergoing change of shape and dissolution.

The smallest individuals thus attributed to *Trichonympha* are spherical, ovoidal, or pyriform, 0.009 mm. to 0.012 mm. in diameter, or about as long as the latter measurement, and as broad as the former. Larger individuals of elliptical form, narrowing in front and obtusely rounded or sometimes truncate behind, measure from 0.035 mm. to 0.045 mm. in length with little more breadth than the smaller ones. The greater number of immature individuals are fusiform with the anterior extremity somewhat produced and mammilliform, or it may be more conical and pointed, while the posterior extremity is acute, or not unfrequently more or less prolonged into a caudate appendage of variable shape. These forms range from 0.03 mm. to 0.055 mm. in length by 0.015 mm. in breadth; but occasionally they range from the latter length to 0.09 mm., and from the latter breadth to 0.018 mm. Rarely some fusiform individuals were observed ranging from 0.1 mm. long by 0.02 mm. wide to 0.16 mm. long and attenuated to 0.012 mm. wide.

The supposed immature *Trichonymphæ* do not exhibit the conspicuous division into two parts, nor the distinctness of structure presented by the perfect animal.

They, however, show what seems to be an approach to both conditions indicated. Their structure consists of an indistinctly granular basis with coarser granules, but the anterior extremity to a variable extent is clearer or devoid of the coarser granules, and there is no trace of differentiation between endosarc and ectosarc. A nucleus if present is completely obscured from view.

Cils clothe the entire body of the young *Trichonympha*, and though of considerable length are not remarkably so as in the mature animals, nor do they exhibit the distinction of several ranks or series as in the latter. The cils appear to originate in opposite spiral lines crossing each other, and give to the animal a more or less imbricate appearance with a serrated aspect on the lateral outlines. The cils fold backward and outward from the head and become longer posteriorly.

The young *Trichonympha* advances, in a rather slow, shuffling manner, wriggling slightly from side to side, and sometimes elongating and shortening. The cils wave with moderate rapidity in a flowing manner outwardly and backward.

Sometimes individuals are to be seen intermediate in character with those above described and the mature *Trichonympha*, as represented in Fig. 11. In this state the creature is ovoid with the narrower extremity conical and directed forward. It exhibits a marked differentiation of structure into two parts, and also a distinct central nucleus, but presents no distinction of integument. The posterior part of the body is distinctly and somewhat coarsely granular, while the anterior part is more transparent and homogeneous. The animal is invested with cils resembling those of the mature animal, but apparently starting from spiral lines on the anterior clearer division of the body. The individual represented was 0.06 mm. long by 0.036 mm. wide.

What may be said of the character and position of *Trichonympha* in the animal series? It bears considerable resemblance to a *Gregarina*. Both exhibit the same general form and division into two parts; and both possess an equally consistent integument or ectosarc impenetrable to the passage of food, and decidedly contractile. *Trichonympha* usually appears to contain more or less solid food, which, being the case, must enter by a mouth the position of which I failed to detect. *Gregarina* does not take solid food, and, therefore, needs no mouth.

The interior substance of *Trichonympha*, or endosarc in two divisions, as in *Gregarina*, is of more consistent character, and does not present the fluent condition in the latter. The nucleus of *Trichonympha* appears to occupy the anterior division of the endosarc, and is fixed in position; in *Gregarina* it occupies the posterior division of the endosarc, and is readily displaced in the flow of the latter.

Trichonympha is especially remarkable for its wonderful cloak of vibratile cils, absent in *Gregarina*, though even *Monocystis*, a related form of the earth-worm, in one of its stages, is clothed with long cils, but they appear not to be vibratile.

The absence of all trace of a vascular, nervous, and special reproductive system would exclude *Trichonympha* from the class of worms.

In conclusion, *Trichonympha* has appeared to me to be a Protozoan intermediate to the Gregarines and Infusorians, but more nearly related to the former.

PYRSONYMPHA.

Pursos, a flame; numpha, nymph.

PYRSONYMPHA VERTENS. Plate 52, Figs. 1–17.

Proc. Acad. Nat. Sci. Philad. 1877, 148.

The parasite of the Termite, distinguished by the above name, is a constant associate of *Trichonympha*, and occurs commonly even in much greater abundance. It is usually not so large, but occasionally reaches a greater size. It is of more delicate constitution, and more readily undergoes change and dissolution after removal from the intestine of its host. Very many, indeed, undergo immediate and rapid destruction on being transferred to the field of the microscope, diffused in the fluids commonly employed in such examinations, though others remain for variable periods extending to some hours with comparatively little change.

When first observed, though the animal usually remains stationary or nearly so in position, its movements are so active and varied that it is difficult to obtain a clear idea of its form and structure. In its rapid motion it gives one the impression of a flaming body. It writhes about and bends and unbends in a zigzag manner, while rapid undulatory movements pursue a longitudinal course in a more or less spiral manner from one end to the other. (See Figs. 1–6, Pl. 52.)

When the movements of *Pyrsonympha* become sufficiently retarded to permit a better view of its character, it usually appears of variable proportionate length and breadth and of clavate form, as represented in Figs. 1–6. It exhibits no distinction of parts, as in *Trichonympha*, and is composed of finely granular protoplasm mingled with variable proportions of coarser granules, but shows no clear differentiation of an integument or of ectosarc and endosarc.

The narrower extremity of the body of *Pyrsonympha*, holding an advanced position, is usually to a variable degree clearer or more transparent than the broader portion. This commonly contains variable proportions of darkly outlined, more or less angular particles, which I have viewed as solid food, consisting of

fragments of wood-fibres, vessels, and cellular tissue, derived from the food of the host. Among these sometimes wood-fibres of considerable length may be observed, as seen in Fig. 4.

The anterior end of *Pyrsonympha* is conical, or may become more or less obtusely rounded or truncated. The posterior broader extremity is usually rounded, or more or less angular or acute. Often also it is more or less tapering, and frequently somewhat acuminate. Sometimes, too, it appears terminated by a caudal appendage of variable form and length, but this has seemed to me to be a production resulting from change due to dissolution.

The sides of the body exhibit undulating, longitudinal folds proceeding from the narrower towards the broader extremity of the body, which accord with corresponding movements of the surface. These are especially obvious along the lateral outlines of the body. The folds pursue a more or less spiral course, and from the translucency of the animals appear to decussate from opposite sides. They become more pronounced with greater activity, and often they seemingly terminate in a series of prominent points to one side of the broader extremity of the body, as represented in Figs. 1–3. At other times their deeply waving and spiral course gives the animal the appearance of a screw rotating on its axis, as seen in Figs. 8–12.

In my earlier observations on *Pyrsonympha* I supposed the undulatory movements of the body were due to cils, though ordinarily these were not perceptible. In very many of the swarms examined with the utmost scrutiny I failed to detect these organs, especially in the large and more conspicuous forms as well as in others of somewhat peculiar character. Whether examined in the fresh and most active condition, in the decline of their power, or after the cessation of movements, the *Pyrsonymphæ* appeared to be entirely destitute of cils, as represented in Figs. 1–4, 8–12.

In some cases variable numbers of *Pyrsonympha*, especially smaller ones, but not unfrequently also large individuals, appeared to be invested with cils, sometimes more or less obscurely, and at others quite distinctly, as seen in Figs. 5–7.

In some later observations, in many swarms of *Pyrsonympha*, the greater proportion or nearly all were distinctly invested with cils, as represented in Figs. 14–17. These were generally smaller than those which appeared to be entirely destitute of cils, but otherwise seemed to be identical. Many presented the usual clavate form, vigorously bending in zigzag, as in Fig. 14; others were more or less fusiform, and actively writhing, as in Figs. 16, 17. Among them were vari-

able proportions, of comparatively large size, apparently destitute of cils, like that of Fig. 4, and many like those of Figs. 8–12, upon which no trace of these organs could be detected.

Regarding all the forms above indicated, whether ciliated or nonciliated, as pertaining to *Pyrsonympha*, I have supposed that the former condition probably was the less mature one, and that the cils were shed as the animal assumed the mature condition.

In addition to the undulating lines of the surface of the body or the ciliary investment, it would appear that *Pyrsonympha* possesses another accessory to movement. This is usually seen, more or less distinctly, as a cord, narrow fold, or doubly-contoured line, extending from one end of the body to the other. This incessantly and vigorously waves in a rhythmical manner, commencing at the narrow and proceeding to the broad end of the body, and quickly recommencing at the former, so that the movement appears to be continuous in a circle. The waves pursue a long, angular, zigzag course, in accordance with and appearing to produce corresponding movements of the whole body. The motion of the undulating cord and of the animal together impressed me with the idea of a snake in a bag, making its presence obvious in active contortions. In a less active condition of the undulating cord of *Pyrsonympha*, instead of the conspicuously zigzag movements of the body, it appears to produce a writhing motion. In the process of dissolution of the animal, the undulating cord often appears to project to a variable extent from the narrower end of the body. After death it remains more or less persistent, as seen in Fig. 13. Viewed on end, while *Pyrsonympha* remains nearly or quite stationary in position, the zigzag motion of its body, seemingly due to the vigorous action of the undulating cord, gives it the appearance of a rotating wheel with an angular tire.

With the incessant zigzag motion, or the less conspicuous one of the body, less vigorous but rapid undulatory movements proceed in longitudinal more or less spiral lines of the surface, giving to the animal the appearance of a flame.

A large nucleus is present in *Pyrsonympha*, though in the most active condition of the animal it is more or less obscured, and often is completely concealed by other contents of the body, but becomes quite evident in dissolution of the latter. It usually occupies a position in the narrower extremity in advance of the middle, but occasionally is situated in the broader part. It is oval or round, and often appears ovoid or pyriform, with the prolongation in advance.

When *Pyrsonympha* undergoes dissolution and dies, it discharges most of the

contents of the body, and assumes an oval or spherical shape, while the nucleus becomes more distinct, and the undulating cord remains more or less persistent, as seen in Fig. 13.

Pyrsonympha commonly measures from 0.1 mm. long by 0.03 to 0.04 mm. wide at the broader part, to 0.15 mm. long by about the same width. The longest individual measured was 0.16 mm. long by 0.033 mm. wide. The nucleus measures 0.016 mm. in diameter, or in oval form 0.024 mm. by 0.012 mm. The screw-like nonciliated forms, such as represented in Figs. 8–12, commonly range from 0.075 mm. long by 0.015 mm. wide to 0.12 mm. long by 0.015 to 0.025 mm. broad; but often equal the others in size. Distinctly ciliated individuals, elongated and fusiform, measured 0.075 mm. to 0.09 mm. long by 0.009 mm. to 0.012 mm. wide; and the clavate forms 0.06 mm. to 0.075 mm. long by 0.018 mm. to 0.024 mm. wide.

Pyrsonympha, though usually observed in a stationary position while it bends and unbends, or writhes from side to side, may sometimes be seen moving about in a slow, shuffling manner. Though it appears to take solid food, I was unable to detect the mode of its entrance. At no time did I detect within the animal distinct vacuoles or a contractile vesicle.

The animal I take to be a ciliated Infusorian, though in many individuals, perhaps in a particular stage of life, the cils appear to be absent.

DINENYMPHA.

Dine, whirl; numpha, nymph.

DINENYMPHA GRACILIS. Plate 52, Figs. 18–26.

Proc. Acad. Nat. Sci. Philad., 1877, 149.

To the parasitic community of our Termite belongs the animal above named. It is a ciliated Infusorian, probably related with the familiar genus *Opalina*, though, unlike this, and like its associates, it appears to swallow solid food. Since I have had the opportunity of observing ciliated forms of *Pyrsonympha*, I have suspected that perhaps this also is only a younger stage of the former. The body is a simple band with tapering extremities and pointed ends. It is longitudinally striated, and is translucent, pale, and indistinctly granular, without a clear differentiation into endosarc and ectosarc. Commonly the central portion of the body contains variable proportions of coarse granules, and some irregular particles probably of the nature of food, and seemingly minute fragments of wood-fibre derived from the food of the Termite. Not unfrequently one or several

clear globules may be seen, which are probably vacuoles. Usually a nucleus could not be detected, but on dissolution of the animal one becomes more or less evident in the forepart of the body.

Dinenympha is everywhere closely invested with short, rapidly-vibrating cils; distinctly obvious along the outline of the body. In many instances individuals appear with the head end furnished with a sort of crest, or radiant fascicle of longer cils, as represented in Figs. 25, 26. In most cases the crest was not obvious, and when present I have suspected that perhaps it was illusory, and due to the temporary adherence of Vibrios, which occur as an abundant associate of the animal parasite.

Dinenympha is an active creature incessantly in motion, though like its associates it remains nearly or quite stationary in position. It always appears twisted, or presents from one to three spiral turns on its long axis, so that it seems to be in constant rotation, while it writhes about and alternately elongates and shortens. The anterior end also bends in one and then in another direction, and is often alternately somewhat projected and withdrawn. Sometimes the animal slowly advances in a shuffling manner, alternately inclining from side to side. In its apparent rotary movement the longitudinal striæ of the body become more or less pronounced, and at the lateral borders of the turns of the spiral induce a dentated appearance. *Dinenympha* ranges from 0.045 mm. to 0.096 mm. in length by 0.006 mm. to 0.012 mm. in breadth.

On one occasion only in a single Termite I observed numerous *Dinenymphæ*, in which the body contained a variable number of comparatively large, spore-like bodies, as represented in Fig. 22. They were oval, darkly outlined, translucent, homogeneous, oil-like in appearance, and measured about 0.006 mm. by 0.0045 mm. Usually there were two or three, but ranged from one to five or more. A number together always formed a single row, and they appeared flattened at the points of contact.

These bodies I supposed might be spores or reproductive bodies of the *Dinenympha*, but I also observed a number of the young *Trichonympha*, as represented in Fig. 21, Pl. 51, containing variable numbers of the same kind of bodies. Nevertheless these may be spores of the *Dinenympha*, which after expulsion had been swallowed by the *Trichonympha*. It has further occurred to me that they might be spores of some parasite of the parasites named.

Occasionally I have observed a nucleus in *Dinenympha*, occupying a nearly central position.

ISACIS.

ISACIS MIGRANS.

Lespes. Annales Sci. Nat. V., 1856, 335.

In numerous examinations of the parasites of our Termite, always directed to those of the intestines, I but once met with an individual of the thread-worm, which I recognized as the *Isacis migrans*, discovered by M. Lespes in the Termite of France. While in the act of writing the present notice of the worm, I laid down my pen and reflected upon its comparative rarity in our Termite. Recalling to mind the frequent occurrence of a nematoid parasite in the proboscis of the common house-fly, it occurred to me that the *Isacis* might inhabit the head of the Termite. Having a colony of the latter on my table, I at once took two individuals and examined their heads, and behold in a moment I had displayed beneath the microscope about a dozen individuals of the *Isacis*.

In the Termite of France, and likewise in our own, the *Isacis* occurs in an immature condition; that is to say, without the generative apparatus being developed. In the mature state M. Lespes found the worm in earth of the nest of the Termites, and it is probable that it will be found in the same state under like circumstances with our Termites.

GREGARINA

GREGARINA TERMITIS. Plate 52, Fig. 27.

A small *Gregarina* was once noticed in our Termite, and is represented in Fig. 27. The body is ovoid with the narrower end posterior. The head spheroid compressed from above downward. Length 0.06 mm.; head 0.018 mm. long, 0.03 broad; body 0.036 mm. broad.

Of the vegetal parasites found in association with the animal forms, within the small intestine of our Termite, there are two kinds: one a species of vibrio, the other an attached algoid, to which I formerly gave the name of *Arthromitus*.

VIBRIO.

VIBRIO TERMITIS. Plate 52, Figs. 36–39.

Vibrios occur in great numbers as an associate of *Trichonympha*, *Pyrsonympha*, and *Dinenympha*. They resemble most nearly the *Vibrio serpens* of Müller, as described by Dujardin, Cohn, and others. Under the highest powers of the microscope at my command, one-tenth objective of Wailes, of Smith and Beck, and No. 11 immersion objective of Hartnack, they appear as immeasurably fine lines, usually ranging from 0.03 mm. to 0.045 mm. in length; but in

extreme ranging from 0.015 mm. to 0.06 mm. in length. They usually appear rectilinear and regularly undulant with from three to five or six waves. They commonly remain stationary in position and undulate more or less rapidly, but they often advance or recede with variable rapidity, and sometimes become quiescent. Occasionally they bend at an obtuse angle while continuing to undulate, and sometimes they become zigzag. Mostly they wave with regularity, sometimes irregularly, and occasionally the ordinary number of their waves is doubled. The smallest individuals, 0.015 mm. in length, are straight, but in movement become bent in the segment of a circle or become sigmoid.

The vibrios move in all directions among their associates. Not unfrequently numbers adhere together by one end and form radiating groups, as represented in Fig. 38.

ARTHROMITUS.

Arthron, a joint; mitos, a thread.

ARTHROMITUS CRISTATUS. Plate 52, Figs. 28–34.

Leidy. Proc. Acad. Nat. Sci., IV., 1849, 227. A Flora and Fauna within Living Animals, Smithsonian Contributions, 1851, 34.

The name of *Arthromitus* was originally given by the author to a supposed undescribed genus of delicate filamentous plants, found growing within the intestine of certain myriopods, *Spirobolus marginatus* and *Polydesmus virginiensis*, and of the coleopterous insect *Passalus cornutus*.

The characters of the genus *Arthromitus* are as follows: Plant in the form of exceedingly fine delicate filaments, usually attached by an attenuated extremity and growing isolated or in small divergent groups. Filaments always simple, cylindrical, of uniform diameter, homogeneous, and inarticulate, or more or less distinctly articulate, with the free end slightly expanded or narrowed, and rounded or truncated. Articuli mostly cylindrical, with little difference of length and breadth, sometimes feebly keg-shaped, homogeneous. Spores mostly in a series occupying the distal articuli, always single, oval or oblong, darkly outlined, translucent, and homogeneous.

Among the profusion of parasites obtained from the small intestine of our Termite almost always a number of filaments may be observed with the characters above ascribed to *Arthromitus*. They are usually observed loose, and have been probably detached from their points of growth. When attached they appear to spring singly or in groups of several together from a granule or minute round disk adherent to the epithelium of the intestine.

The finest filaments appear homogeneous and inarticulate. The larger and mature filaments, or those bearing spores, as represented in Figs. 28–32, reach half a millimetre or more in length, and measure from 0.0015 mm. to 0.00375 mm. in thickness. Usually at their distal portion they exhibit a more or less long series of spores, distinctly defined, giving to the filaments the appearance of minute rows of beads. The number of spores in a row is variable, and sometimes several rows occur, with a short interval, in the same filament.

The spores are commonly oval or oblong, and lie longitudinally at pretty uniform distances apart; but occasionally they are a little oblique. They are strongly marked, darkly outlined, transparent, and homogeneous, and resemble minute oil-drops. Under a favorable disposition of the light each is seen to occupy a separate articulation, and the partitions separating them are more or less distinctly observable, as represented in Figs. 31, 32.

Commonly the spores measure about 0.003 mm. long by 0.0022 mm. broad.

Sometimes filaments occur in which the spores lie together in pairs with a slight separation between each spore, and wider spaces between the pairs, as seen in Fig. 28. Other filaments appear in which the spores are proportionately much longer than usual, and separated by wider intervals, as seen in Fig. 30. It would seem from these latter kinds of filaments, as if the longer form of spores underwent division in the production of the pairs.

The filaments below the spore-bearing portions sometimes appear slightly more attenuated and less distinctly or not articulated.

Occasionally finer, homogeneous filaments of the plant grow upon the more mature ones, as represented in Fig. 32.

The *Arthromitus* of the Termite, by comparison with specimens of *Arthromitus cristatus*, from our Wood-Julus, recently examined, prove the plants to be the same. A bunch of *Arthromitus* from the latter animal is represented in Fig. 33. The spore-bearing filaments are about the same size as in those of the Termite, but frequently they present more numerous or longer rows of spores, and in the filaments without spores an articulated condition is at times more evident.

In some of the spore-bearing filaments from Julus, it was observed that the articulations appeared less well defined than usual, as if softened, and they were finely granular, as represented in Fig. 34. The condition was supposed to indicate the means by which the spores may be discharged. Attached to some of the apparently softened filaments there were many small, narrow, elliptical bodies, which appeared to be germinating plants. They were not derived from the spores, than which they were smaller, but started from minute granules, seemingly some of those derived from the softening articulations.

It becomes a question as to the claim of *Arthromitus* being a genus distinct from others previously proposed or established.

Valentin (Repertorium f. Anatomie, 1836) described a parasitic plant from the large intestine of *Blatta orientalis*, and from the rectum of *Astacus fluvialis*, under the name of *Hygrocrocis intestinalis*, which would appear to have the same generic character as *Arthromitus*. Not having access to the original description, I quote the diagnosis as given by M. Ch. Robin (Histoire d. Vegetaux Parasites, 1853): "Fila simplicia, tenuissima, perlonga (articulata?), serpentia, apice recta (moniliformia? articulis globosis?)." This would apply to the plants I have referred to *Arthromitus*, except in the latter two characters, which, however, are questionable with the author as applied to *Hygrocrocis intestinalis*.

Recently I was so fortunate as to catch a large cockroach, *Blatta americana*, when I proceeded to examine the large intestine with the expectation of finding the same parasitic plant as that discovered by Valentin in the *B. orientalis*. Surely there it was in abundance, in association with the usual animal parasites, and in it I recognized *Arthromitus;* but with sufficient peculiarity, perhaps, to view it as a species distinct from that of our Wood-Julus and Termite.

The *Arthromitus* of our cockroach consists of simple filaments, about the same diameter as those of the Julus and Termite. The stouter spore-bearing filaments, as represented in Fig. 35, Pl. 52, exhibited more numerous or longer rows of spores which were of the same form as those of *Arthromitus cristatus*, but were differently disposed. They were transversely situated, often alternating in direction, as seen in the figure. Occasionally they were oblique, but in no instance longitudinal. This difference of position is due to the difference in the proportionate size of the articulation in the two forms of *Arthromitus;* the joints in that of the cockroach being broader than long, while in *A. cristatus* the condition is reversed. In the latter the lines of separation of the articulations are commonly most readily detected between the ripe spores, but in the *Arthromitus* of the cockroach the partitions were better seen in the filament below the spore-bearing portion, as seen in Fig. 35.

I have assumed that the *Arthromitus* of the *Blatta americana* is the same as the *Hygrocrocis intestinalis* of the *Blatta orientalis*, though it may be different.

The genus *Hygrocrocis* was originally proposed by Agardh (Systema Algarum, 1824), on certain fine filamentous plants, growing in chemical solutions, which are rather of the nature of Fungi. Rabenhorst excludes it from his Flora Europæa Algarum, and in a note indicates it as pertaining to the Fungi.

M. Robin refers the *Hygrocrocis intestinalis* of Valentin to the genus *Lepto-*

thrix. The characters of this, as originally established by Kützing (Phycologia Generalis, 1843, 150), are as follows: "Trichomata ex articulus globosis vel ellipticis, solidis, non vaginatis, minutissimis, arcte conjunctis composita, plerumque moniliforma, aut libera, aut in stratum lubricum, amorphum implicata." The genus included minute filamentous algæ growing parasitic on other and longer algæ, and on other aquatic or submerged plants and on rocks.

M. Robin also refers the algous filaments growing on the human teeth to the same genus, under the name of *Leptothrix buccalis*. The fine threads of this are inarticulate, homogeneous, and without evident spores. Rabenhorst (Flora Europæa Algarum, I., 1865, 73) says of the subfamily to which *Leptothrix* belongs: "Propagatio adhuc ignota."

The essential characters of *Leptothrix* apply sufficiently well to the parasitic algæ I have described under the name of *Arthromitus*, but as the spores of the former remain unknown, it would, perhaps, be of doubtful propriety in the present condition of our information to drop the latter name.

M. Robin further describes a parasitic plant, found in the rectum of *Julus terrestris*, and in *Dytiscus marginalis* under the name of *Leptothrix insectorum*. While I suspect that this may pertain to *Arthromitus*, the figures of the filaments exhibit a structure such as I never saw in the latter, and they show no spores such as pertain to *Arthromitus*.

In conclusion, as if to fill up the measure of life capable of being sustained by the Termite, it is infested with a mite, a species of *Gamasus*.

REFERENCES TO THE PLATES.

PLATE 51.

TRICHONYMPHA AGILIS. All the figures magnified 666 diameters.

Figs. 1–3. Side views of three individuals, seen immediately after escaping from the intestine of the Termite. The head more or less depressed within the body, and the third rank of cils widely spread. The central nucleus distinctly visible. In these views the animal appears broader than long.

4. An individual as seen from above or below, with the cils extended in four chief divisions.

5. Side view of an individual fully extended.

6. The same individual as seen with the head rolled into a helix.

7. Side view of an individual with the body much shortened and widened, and containing, besides the usual nucleus, two large, coarsely granular balls, supposed to be masses of spores.

8. Individual with the body shortened and widened and with the head enrolled into a helix. The nucleus apparently contained within the sunken endosarc of the head.

9. Side view of an individual. The usual nucleus inclosed within a larger sphere.

10. Similar view of another individual.

11. Side view of an apparently immature individual.

12, 13. Apparently less mature individuals, with a seemingly imbricated arrangement of structure, and no visible nucleus.

14–20. Similar views of different individuals supposed to be immature forms of the same animal.

21. View of an individual of the same kind, containing numerous spore-like bodies.

PLATE 52.

Figs. 1–17. PYRSONYMPHA VERTENS. All 666 diameters.

1. Side view of a nonciliated individual in zigzag movement, together with lateral undulating motion of the borders in the direction of the arrows. The interior nucleus visible.

2. An individual extended, the zigzag motion retarded. The nucleus pyriform; the prolongation apparently the result of change. A large quantity of food visible in the broad part of the body.

3. An individual exhibiting an extreme condition of zigzag bending.

4. A large individual, after slackening in its zigzag motion. Several long wood-fibres visible in the interior.

5–7. Three ciliated individuals. All with the nucleus visible, and all containing some particles of wood-fibre.

8-12. Five apparently nonciliated individuals with rapid undulating movement in spiral lines.

13. A dead individual retaining the nucleus and undulatory cord.

14. Lateral view of a ciliated individual.

15. End view of the same.

16–17. Two ciliated individuals of narrow fusiform shape.

18–26. DINENYMPHA GRACILIS.

18. A large individual, containing considerable food. 666 diameters.

19–21. Three individuals, exhibiting different forms assumed in movement. 750 diameters.

22. Individual, containing a row of spore-like bodies. 666 diameters.

23, 24. Two small individuals. 666 diameters.

25, 26. Two individuals, apparently with a fascicle of long cils at the upper end. 500 diameters.

27. GREGARINA TERMITIS. 666 diameters.

28–34. ARTHROMITUS CRISTATUS. All 1333 diameters except Fig. 33, which is 666 diameters.

28. Filaments with spores in pairs, separated by wide intervals.

29. Filaments with slightly oval spores.

30. Filament with elongated spores.

31. Comparatively robust filament with spores, arranged as usual, with the partitions of the articulation visible.

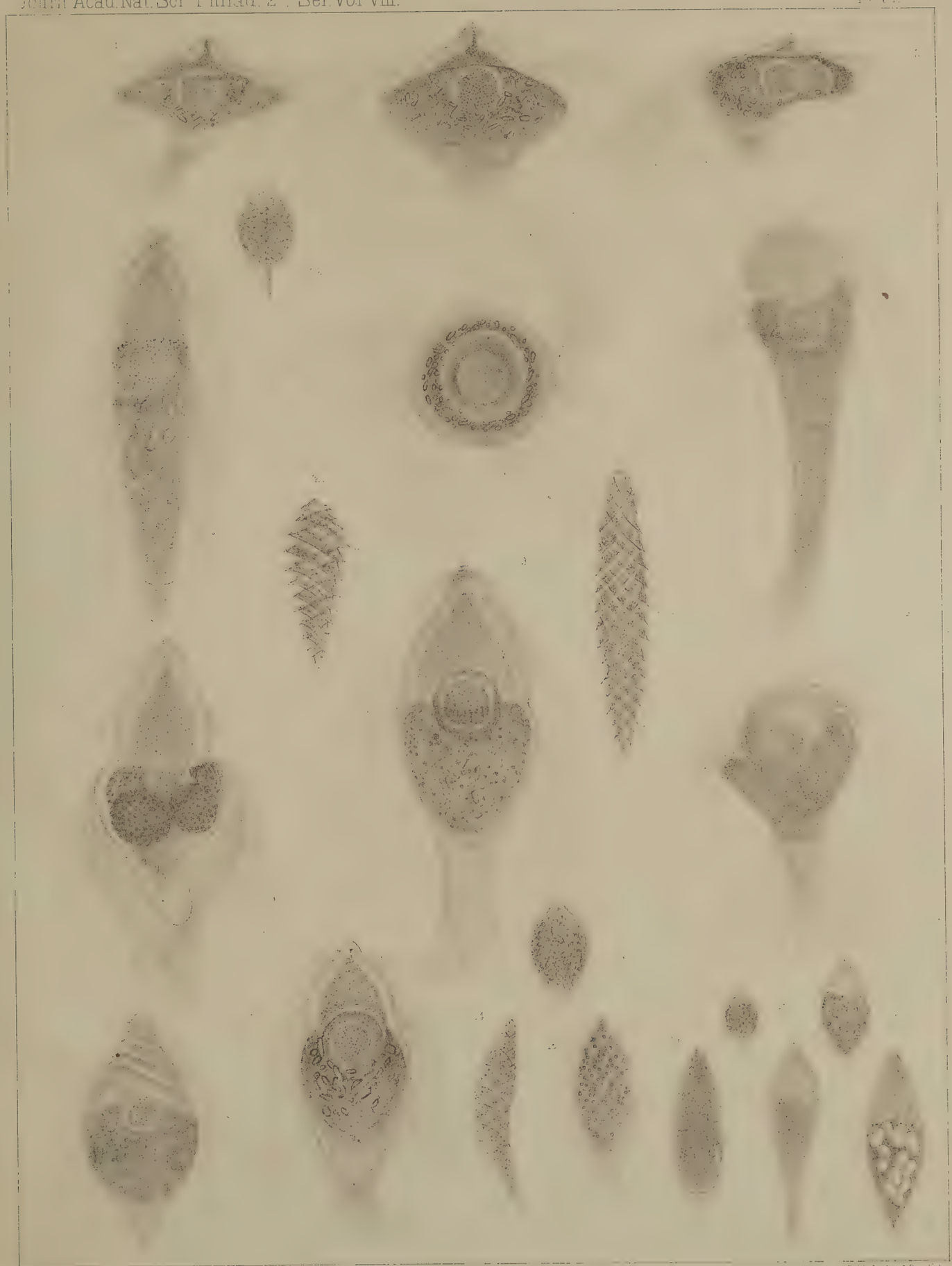
32. A robust filament, with spores and distinct articulations, and with young plants attached.

33. A bunch of *Arthromitus* from *Spirobolus marginatus*.

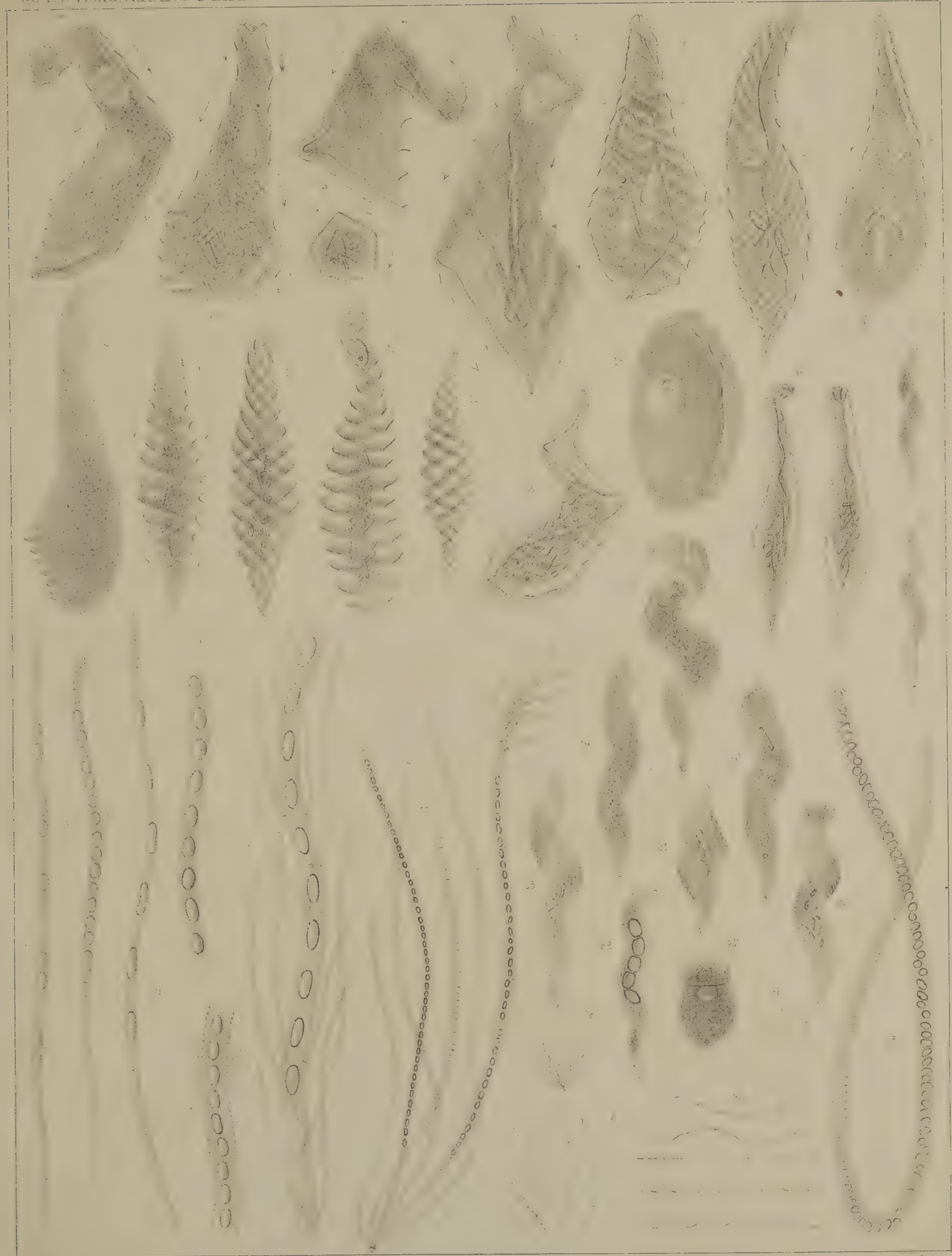
34. Portion of a filament, with spores, the articulations of the filament granular in appearance, and with attached germinating granules.

35. ARTHROMITUS INTESTINALIS. From the large intestine of *Blatta americana*. 1333 diameters. The spores seen in a transverse position.

36–39. VIBRIO TERMITIS. 333 diameters except those of Fig. 39, which are 666 diameters.



TRICHONYMPHA AGILIS.



Thos Sinclair & Son, Lith

1-17 PYRSONYMPHA VERTENS. 18-26 DINENYMPHA GRACILIS. 27 GREGARINA TERMITIS
28-34 ARTHROMITUS CRISTATUS. 35 A. INTESTINALIS. 36-39 VIBRIO TERMITIS